Water Heaters and Storage Tanks

Ecodesign and Energy Label

Review Study

Task 6

Options

FINAL REPORT


Prepared by

VHK, for the European Commission

July 2019

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EXECUTIVE SUMMARY

The aim of Task 6 is to make an inventory and analysis of policy- and design options for review of the water heater regulations 812/2013 (Energy Label) and 814/2013 (Ecodesign).

The report discusses horizontal options (Chapter 2), options for single products as addressed mainly in the Ecodesign regulation (Chapter 3), options for packages of water heating generators (Chapter 4). The final chapter contains a first, mainly qualitative analysis of costs and benefits (Chapter 5).

Horizontal options include:

- Green hydrogen (H₂-ready) and biogas: Making combustion-type water heaters ready for carbon-neutral EU.
- New primary energy factor and other considerations: Consequences for the minimum Ecodesign energy efficiency limits and Energy Label class limits.
- Verification tolerances: Preliminary outcomes of the ECOtest project.
- Third party verification: Could the space heating discussion apply also to water heaters?
- Ecodesign limits for XXL, 3XL, 4XL.
- Clearer definition of drinking water and include carbon-neutral fuels where appropriate.

Options for regulation of single products

- Clarifying hot water storage tank test standard: Picking the right one(s).
- Energy label: Avoid double testing between Ecodesign and Energy Label requirements.
- Adopt NOx-limits for 3rd family gases.
- Is it about time to phase out pilot flames?

Options for packages

- Solar device energy label: Simplifying to boost sales of this renewable, carbon-free energy source.

Note that this report contains proposed options and an overview of the first stakeholder-reactions on the proposals, which would then only be a first input for the Commission-led further consultation on revisions.

This report can only present the main stakeholder comments. For a full overview, please consult the comments and papers on the project website www.ecohotwater-review.eu.
### Acronyms and Units

#### Acronyms

<table>
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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>3XS/XXS/X</td>
<td>Size classes for water heating tapping patterns, from very small XXS to medium M to very large 4XL</td>
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<td>S/S/M/L/XL/XXL/3XL/4XL</td>
<td>Size classes for water heaters</td>
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<tr>
<td>813/2013</td>
<td>Ecodesign Commission Regulation (EU) No. 813/2013 for dedicated water heaters</td>
</tr>
<tr>
<td>CC</td>
<td>Conversion Coefficient (here equal to pef)</td>
</tr>
<tr>
<td>CH</td>
<td>Central Heating</td>
</tr>
<tr>
<td>CO</td>
<td>Carbon Monoxide</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide (R744 as refrigerant)</td>
</tr>
<tr>
<td>(m)CHP</td>
<td>(micro) Combined Heat and Power</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>EED</td>
<td>Energy Efficiency Directive</td>
</tr>
<tr>
<td>e-fuels</td>
<td>Electro-fuels (gas/oil produced with carbon-neutral electricity through electrolysis, methanation, etc.)</td>
</tr>
<tr>
<td>ENER</td>
<td>EC, Directorate-General Energy</td>
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<tr>
<td>GCV</td>
<td>Gross Calorific Value (of a fuel)</td>
</tr>
<tr>
<td>GHP</td>
<td>Gas-fired heat pump</td>
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<tr>
<td>H₂</td>
<td>Hydrogen</td>
</tr>
<tr>
<td>HC</td>
<td>Hydrocarbons</td>
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<td>HT</td>
<td>High Temperature</td>
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<td>LCC</td>
<td>Life Cycle Costs</td>
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<td>Least Life Cycle Costs</td>
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<td>LT</td>
<td>Low Temperature</td>
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<td>MCP</td>
<td>Medium-Sized Combustion Plants</td>
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<td>MSA</td>
<td>Market Surveillance Authority</td>
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<td>NBR</td>
<td>Nitril Butadiene Rubber</td>
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<td>NCV</td>
<td>Net Calorific Value (of a fuel)</td>
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<td>NH₃</td>
<td>Ammonia</td>
</tr>
<tr>
<td>NOₓ</td>
<td>Nitrogen oxides</td>
</tr>
<tr>
<td>PE</td>
<td>Polyethylene</td>
</tr>
<tr>
<td>pef</td>
<td>primary energy factor</td>
</tr>
<tr>
<td>PEM</td>
<td>Proton Exchange Membrane</td>
</tr>
<tr>
<td>POM</td>
<td>Polyoxymethylene</td>
</tr>
<tr>
<td>PVC</td>
<td>Poly Vinyl Chloride</td>
</tr>
<tr>
<td>RRT</td>
<td>Round Robin Test</td>
</tr>
<tr>
<td>SOFC</td>
<td>Solid Oxide Fuel Cell</td>
</tr>
<tr>
<td>VHK</td>
<td>Van Holsteijn en Kemna (author)</td>
</tr>
<tr>
<td>WP</td>
<td>Working Package</td>
</tr>
<tr>
<td>η</td>
<td>Efficiency</td>
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### Parameters

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<td>Q</td>
<td>Heat output [kWh]</td>
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<tr>
<td>η</td>
<td>Efficiency [-]</td>
</tr>
<tr>
<td>h</td>
<td>Hours</td>
</tr>
<tr>
<td>K</td>
<td>Degree Kelvin</td>
</tr>
<tr>
<td>kWh</td>
<td>Kilo Watt hour</td>
</tr>
<tr>
<td>°C</td>
<td>Degree Celsius</td>
</tr>
<tr>
<td>a</td>
<td>Annum (year)</td>
</tr>
<tr>
<td>W</td>
<td>Watt</td>
</tr>
</tbody>
</table>
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1 INTRODUCTION

1.1 Scope

The scope of Task 6 is to make an inventory of policy- and design options for review of the (dedicated) water heater regulations 812/2013 (Energy Label) and 814/2013 (Ecodesign). In principle, this includes an assessment of costs and benefits and –where possible— a calculation of Life Cycle Costs and Payback Periods per design option. However, it must be noted that this is a review study and the focus is not necessarily on setting new limits at Least Life Cycle Costs (LLCC), but rather on improving the regulations based on experience and new insights.

The overall aim is to make the water heater regulations more effective (more impact) and more efficient (with lower burden/costs) in view of the policy objectives on climate change, energy efficiency, renewables, extra-EU energy dependence, air- and water pollution, internal market, circular economy, etc..

In the 2017 Energy Label Regulation and by way of exception, the current scheme of 10 labelling classes, from A+++ to G, can be maintained for this product group at least until 2025 (instead of the 7 classes A-G for most other product groups).

Task 6 also will address the questions from the review clause of the 814/2013 regulation regarding the appropriateness of Ecodesign requirements for GHG emissions, other emissions (CO, HC, PM), water heaters using biomass gas or oil as well as the validity of the conversion coefficient and the appropriateness of third part certification. Also, the regulation will be reviewed in the light of technological progress.

The review clause of 812/2013 labelling regulation stipulates to consider technological progress and in particular changes in market shares of various types of heaters as well as the appropriateness of a package fiche and label in point 3 of Annex III and point 4 of Annex IV.

This Task report presents design and policy options for the various issues identified in other Task reports, also taking into account stakeholder reactions on proposals presented at the second stakeholder meeting. To further discuss and investigate issues identified, the study team proposes to set up a special consultation initiative with stakeholders.

1.2 Approach

In the comprehensive Task 6 Report of the Preparatory Study of 2007 the main focus was on determining energy efficiency limits at LLCC throughout various tapping patterns (from XXS to 4XL) for various (combinations of) water heating devices. The phenomenon of the tapping patterns seems to have been broadly accepted by the market. However, the stakeholders have requested, at least for Ecodesign, to abandon the holistic approach and distinguish technology-specific minimum energy efficiency limits, distinguishing not just between electric and fossil-fuel fired appliances as was done in the 2017 special review study, but to differentiate even further in various electric and various fossil fuel fired dedicated water heater categories.
Climate change, renewables and other objectives were taken into account in the 2007 Preparatory Study evaluation of saving measures, but only to a limited way in shaping the measures. At the moment, in 2019, it seems that climate change objectives, i.e. the transition to a carbon-neutral society in 2050, take highest priority. The latest developments in that field have been documented in Task 3.

The Task 6 report will thus not repeat the exercise of the 2007 Preparatory Study, but – apart from looking for improvements in general— focus on the new objectives.

The basis of the design options will be the issues that have been discussed in the previous Task reports 1 to 5. After completion of Task 6, the impacts of applying (clusters of) design options, will be calculated in the scenario analysis in Task 7.

1.3 Report Structure
This Task 6 final report contains, after this introductory chapter 1, four chapters where the design options are discussed:

2. Horizontal design options;
3. Options for single water heaters, improving efficiency metrics and/or testing;
4. Options for water heating packages, improving efficiency metrics and/or testing;
5. Other design options (NOx, noise, etc.).
2 HORIZONTAL OPTIONS

2.1 Introduction
Horizontal options are those that apply across various types and water heater technologies. This section will address:

- H₂-ready appliances
- Biogas
- Appliances suited for biogas
- Primary energy factor
- Verification tolerances
- Third party verification
- Labelling scope

2.2 H₂-ready
The 2018 Vision documents presented by the Commission and discussed in Task 3 present various pathways to an (almost) carbon emission neutral society and –depending on the scenario—there is more or less use of carbon-neutral gaseous fuels. Electricity from renewables is used to create hydrogen or hydrogen-based synthetic fuel from water, such as ammonia (NH₃)¹, e-methane, e-methanol, etc..²

Carbon-free versus carbon-neutral
Hydrogen has the unique quality, as opposed to other e-fuels or biofuels, that its combustion or other energy conversion is not just ‘carbon-neutral’ but ‘carbon-free’. Other e-fuels or biofuels, if they are even suitable for space heating¹, produce carbon emissions during combustion or other energy conversion but this is assumed to be compensated by the absorption of greenhouse gases during production of the fuel (e.g. photosynthesis) or by the capture and storage of the carbon emissions at/after combustion a.k.a. Carbon Capture and Storage (CCS). But CCS is controversial³ and biomass is only carbon-neutral when made from waste (e.g. biogas from anaerobic

¹ Liquid at room temperature and thus easier and safer to store than hydrogen, which requires 200-350 bar tanks.
² For a recent discussion of technologies and costs see Malins, C., What role is there for electrofuel technologies in European transport’s low carbon future?, Cerulogy report, November 2017.
The Guardian, 16 Feb. 2018 https://www.theguardian.com/commentisfree/2018/feb/16/itd-be-wonderful-if-the-claims-made-about-carbon-capture-were-true
fermentation of organic waste; biomass from forest maintenance) or backed by equivalent reforestation. In the latter case there are also controversial issues.\(^4\)

**Green, blue and grey hydrogen**

‘Green’ hydrogen comes from the wind and solar driven electrolysis of water. This is the sustainable, carbon-free hydrogen source in the long run that is intended. ‘Grey’ hydrogen is produced from fossil fuels (typical natural gas) with considerable carbon emissions and should not play any role in a carbon-neutral society in 2050. The unique hydrogen-type is so-called ‘Blue’ hydrogen that uses the unique hydrogen quality that its combustion is absolutely carbon-free. It is made from pyrolysis of natural gas (mainly methane CH\(_4\)) in an oxygen-free environment. This process decarbonises the methane, i.e. it is split in hydrogen gas H\(_2\) and solid carbon. The solid carbon black can be put to various good uses. One-sixth of the hydrogen is used for the pyrolysis-process and 83% can be distributed for carbon-free combustion (in a boiler), other conversion (e.g. in fuel cells, for heat and electricity generation) or storage for power generation on days with low wind and/or sunshine. Blue hydrogen can be the interim solution if there is not enough time to produce the green hydrogen needed to meet the Paris goals in 2050.

**Smart hybrid**

Specifically for space- and water heating, however, there could be a new option for days with insufficient renewable energy supply (wind, solar): A smart hybrid of an electric heat pump, hydrogen gas boiler and possibly solar assistance. Instead of using the stored hydrogen to generate electricity, which is then used in heat pumps, the hybrid space heater just switches to hydrogen combustion instead of the electric heat pump for the heat generation. So there is no need for a large scale power plant or a micro-scale fuel cell to produce electricity at considerable energy loss, but instead the hydrogen is used directly for heating. The heating efficiency of that hydrogen boiler will often be less than that of the electric heat pump (also depending on outdoor temperature, dimensioning of the heat pump, etc.) but overall the efficiency will often be better – without the intermediate electricity generation step— and at a lower capital expenditure, not having to invest in electric power generation and -distribution, using the existing gas grid with modest modifications.

**Technology and appliance costs**

Task 4 discusses technical and cost aspects of hydrogen boilers and hydrogen distribution. From the viewpoint of all these aspects no particular problems are expected. Hydrogen-fired boilers exist and are currently applied in several field tests. The adaptation of a gas boiler to a 100% hydrogen (-ready) requires technical adaptations beyond the capabilities of installers, but are perfectly feasible for a manufacturer at a mere €200-300 mark-up. Field tests and long-time industrial experience with hydrogen pipelines indicate the feasibility for a safe and low-cost use of the existing gas-grid for hydrogen distribution with minor adaptations.

**Timing**

There are only 31 years till the 2050 Paris-target and probably the switch from natural gas to a hydrogen gas network will need to be realised well before that (2040?).

\(^4\) Like whether it is not better to leave the forest to be a carbon sink and – for certain crops—competition with food crops
Depending on type, quality, usage, etc. the average age of the boiler varies between 15 and 30 years. It may take 3-4 years (2022-2023?) before any ‘soft’ measures on space heating boilers –e.g. in labelling-- can be implemented; it can take another 3 years (2026?) before there is enough political consensus to make measures mandatory in Ecodesign regulations.

The main question, also from some stakeholders, is whether there will be enough green hydrogen production, i.e. from wind- or solar driven electrolysis of water, and whether the probably scarce green hydrogen should be used for space heating and not transport or industrial processes.

There is no convergence in opinion on these issues. The vision documents presented by the Commission and discussed in Task 3 present various pathways to an (almost) emission-neutral society, and –depending on the scenario – there is more or less use of gaseous fuels for (space & water) heating. Given the uncertainty of which scenario will appear more appropriate 30 years from now, the study team is convinced it is best to keep options open and not close doors for certain scenario's to develop.

Thus it is recommended that ‘H₂-ready’ will become a mandatory Ecodesign requirement as soon as possible.

As is customary in these situations to give time for the market actors to prepare, it is proposed to first introduce the ‘H₂-ready’ concept in the Energy Labelling, i.e. giving a 20% energy efficiency bonus leading to an A+ rating for a single boiler, and then after 2 years make ‘H₂-ready’ mandatory.

**H₂ Stakeholder comments and study team reactions**

Associations of gas utilities (Eurogas, Liquid Gas Europe, Marcogaz), industry of – amongst others— gas-fired equipment (EHI, COGEN, PACE, BDR Thermea, the gas heat pump section of EHPA ) and the few Member States reacting at this stage (Denmark, Belgium, UBA-BAM) are cautiously supporting the hydrogen-option, but believe that further investigation is needed before a decision on concrete measures can be made. There appears to be some support for a hydrogen-icon on the energy label (UBA-BAM, ECOS), but not –at this stage— for an outright bonus. The figure of 20%, inspired by neutralising the pef-change from 2.5 to 2.1 which works in favour of the energy label rating of electric appliances, is also considered premature by these stakeholders.

The position of several stakeholder, especially gas utilities, EHI and EHPA/GHP, seems ambiguous in the sense that there is some preliminary support for hydrogen-promotion, but there seems to be a much stronger concern over a negative effect on the rating of ‘normal’ A-rated condensing gas boilers and misleading the consumers.

EHPA/GHP states that the proposal for 20% bonus for “bio-methane and 20% hydrogen” (Green Gas) products needs to be immediately applicable to TDHPs otherwise it will result in penalization (conversion factor is immediately applicable for electrical products) and they note that the current proposal does not indicate definition of the criteria that would enable the eligibility for the bonus. COGEN and PACE (mCHP project) are in favour of promoting hydrogen, but again would like more study.

Response: In general, the study team agrees on the need for further discussion and study, also in view of the many studies and initiatives ongoing at EU level.
Having said that, already time is running out for a full conversion of the space and water heating appliances park. As an illustration: In 1981, the first mass-produced condensing heating boiler appeared on the market. Today, almost 40 years later in 2019, after extensive incentive-programs and eventually mandatory Ecodesign legislation, still only 50% of the installed fossil-fuel fired heating boilers in the EU is condensing. A 95% conversion in the installed park to condensing technology\(^5\) cannot be expected before 2035, i.e. 55 years after the first introduction of the technology.

If the Paris goals are to be taken seriously there will be practically no fossil gas/oil combustion left in only 30 years (a 'marginal' 3% in $1.5^\circ C$ scenarios). Apart from green electrification, green\(^6\) hydrogen and power-to-x technologies can play an important role in reaching the Paris goals and reaching it in an affordable way, if the gas- and oil boiler appliance industry, supported by utilities, is pro-active. This is confirmed in June 2019 study of the IEA for Japan in the context of the G20, which elaborates various future hydrogen options for space heating. The table below shows a Paris-compatible pathway where heat demand would be expected to represent more than half of global building energy consumption in 2030, with about 500 Mtoe of natural gas used for space and water heating in buildings annually. Of this, theoretical potential hydrogen demand might be on the order of 12–20 Mth\(_2\)/yr in key markets (Canada, the United States, Western Europe, Japan, Korea, the Russian Federation ["Russia"] and China) if all gas boiler equipment installed or replaced at expected stock turnover rates between today and 2030 were hydrogen-ready. Combining this with low-concentration hydrogen blends in the wider natural gas grid gives an upper bound of 14–24 Mth\(_2\) global hydrogen demand in 2030.

### Table 1. 2030 natural gas demand for heat in buildings and indicative theoretical hydrogen demand in selected regions  
(source: IEA, June 2019\(^7\))

<table>
<thead>
<tr>
<th>Region</th>
<th>Natural gas demand (Mtoe)</th>
<th>Competitive price range for hydrogen (USD/kgH(_2))</th>
<th>Indicative hydrogen demand (Mth(_2))</th>
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<tbody>
<tr>
<td>Canada</td>
<td>21</td>
<td>0.8-1.2</td>
<td>0.7-1.1</td>
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<tr>
<td>United States</td>
<td>147</td>
<td>1.2-1.5</td>
<td>5.1-7.7</td>
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<td>Western Europe</td>
<td>80</td>
<td>2.0-3.0</td>
<td>0.5-0.7</td>
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<td>14</td>
<td>2.0-3.5</td>
<td>0.4-0.6</td>
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<td>Korea</td>
<td>11</td>
<td>0.9-1.9</td>
<td>2.8-4.2</td>
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<td>Russia</td>
<td>43</td>
<td>1.5-1.8</td>
<td>1.5-2.2</td>
</tr>
<tr>
<td>China</td>
<td>51</td>
<td>1.2-1.4</td>
<td>1.8-2.7</td>
</tr>
</tbody>
</table>

\(^5\) A full conversion is unlikely, because of exceptions in the regulations.
\(^6\) Green in the long term, green and blue in 2050.
The study team proposes to set up a special consultation initiative with the stakeholders to further discuss and investigate the issue.

It is important to state here that the goal of that discussion will certainly NOT be define the full EU strategy to reach the Paris goals. That is not the role of Ecodesign or Energy Labelling. The goal will be to determine, whatever the Paris-strategy will be, what the heating appliance design can contribute to optimise the chances (or reduce the adverse risks) to meet the Paris-objectives.

Regarding the Task 6 proposal to introduce a labelling-factor/ bonus for carbon-neutral ‘100% hydrogen-ready’ boilers, the vast majority of stakeholders was not in favour. This has to be seen in the light of the fact that the proposal was new, and —as also stated in the stakeholder meeting— needs further discussion and elaboration.

Out of the 20 stakeholders reacting, there are 4 stakeholders that find no merit in the proposal whatsoever, i.e. consumer association ANEC/BEUC, the electric heat pump section of EHPA, heat pump manufacturer Daikin and association EPEE (representing mostly heat pump and air conditioning manufacturers with extra-EU HQ).

The most frequent argument by these stakeholders, citing the 2017 Energy Label Regulation\(^8\), is that the energy labelling should be limited to giving information based on energy efficiency, i.e. ratio of energy input versus performance. The measure reportedly creates confusion and misinterpretation of the actual efficiency of the unit and it is not in line with the purpose of Ecodesign. It would be misleading the consumers because the boilers will not use hydrogen, but are just ‘ready’ to do so and thus there will not be an actual economic advantage.\(^9\)

Response: In the case of biomass in the Solid Fuel Boiler regulation there is a BLF, Biomass Labelling Factor, of 1.45 in the rating of boilers intended for biomass (but often also dual fuel and/or suitable for co-firing with coal). This is purely based on the political decision to promote the use of this fuel as being ‘renewable’. In other words, using factors to change label ratings rather than base them on physically measured energy efficiency is not new and applied in other regulations as well.

As regards the economic gain of H\(_2\)-ready: It is not in the lower energy costs, but it is in avoiding a premature replacement of the boiler, often with product lives over 20 years or more, when the switch from natural gas to carbon-neutral hydrogen(and biogas) has to be made. In that sense, the economics are comparable to buying a ‘HD-ready’ television set in the period 2005-2009 when there was no public High-Definition (HD) broadcasting. Nonetheless, consumers found it a valid argument to buy these TVs instead of the cheaper classic PAL-resolution TVs.

ANEC/BEUC does not agree that hydrogen (H\(_2\)) is good policy solution for (home) heating and does not endorse the notion of H\(_2\) as a ‘carbon-free’ fuel (i.e. GWP of zero). It would be a while before surplus hydrogen from wind and solar would be available, it would be

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\(^9\) ANEC/BEUC, EHPA, Daikin, Denmark, EEB/ECOS are the most outspoken on the issue but others have similar reservations.
too expensive\textsuperscript{10}, etc.. Dutch consumer association \textit{Consumentenbond} believes that the efficiency of using hydrogen will be worse than Joule-heating\textsuperscript{11}. Consumer associations, Denmark and ECOS/EEB believe that hydrogen will be used for transport and industry and not for heating. Within the timeframe of the review study hydrogen should not play a role. The electric division of EHPA Study sees a lack of technology neutrality as the proposal awards bonuses on products that are far from reaching the market and are still in the state of R&D.

\textbf{Response:} The notion that hydrogen and other gas will play a role in the 2050 energy mix for space heating (and water heating) is part of most scenarios of the Commission vision document of November 2018. The discussion on these and other topics in the report are in their early stages. However, the study team is fully aware that this will be the start and certainly not the end of the discussion. The intention is to propose at least one option to meet the policy goal of a carbon neutral Europe in the area of space and water heating.

The arguments in short: Apart from electrification from wind & solar, ambient & geothermal heat (e.g. for heat pumps), other solar assistance (heat and future hydrogen producing panels), some biomass & waste and maybe nuclear energy there is an important case for carbon-neutral gases and in particular hydrogen for space heating, in most European Commission scenarios\textsuperscript{12}. Using carbon-neutral gas is the most economic option in the most recent PRIMES scenarios, saving €335 bn between 2015 and 2050 to reach the Paris goals.\textsuperscript{13} Of all the carbon-neutral gas-options, e.g. biogas\textsuperscript{14}, methanation\textsuperscript{15}, ammonia, etc., green hydrogen is the only one that does not need CCS to be carbon-neutral.

Having said that, the timeframe till 2050 is actually very short, not only for the electrification scenarios (requiring 4 to 6 times more power generation capacity than today), but also to realise a substantial share of ‘green’ hydrogen, i.e. from electrolysis of surplus wind & solar, in the existing 2.21 million km gas grid connected to 118 million EU gas customers. That is why, in a transition period starting much sooner, ‘blue’ hydrogen could be the solution, e.g. from CCU\textsuperscript{16} in decarbonised natural gas through pyrolysis\textsuperscript{17} \textsuperscript{18},

\textsuperscript{10} Citing economists like prof. Mulder from Groningen University. 

\textsuperscript{11} See the elaboration by Consumentenbond (through ANEC-BEUC) in the compilation of stakeholder comments received.

\textsuperscript{12} Commission vision document 28 November 2018.


\textsuperscript{14} Combustion of biogas produces at least as much CO2 as combustion of fossil gas, but because the organic source material absorbs CO2 during its life through photosynthesis and because it is assumed that the organic material used for combustion will be replanted it is assumed to be low-carbon. In the Energy Label for solid fuel boilers biomass gets a labelling factor 1.45. The assumed conversion efficiencies for biomass (physical energy content and technical conversion) in the Fraunhofer study are 0.3 (compared to 1 or 1.1 for fossil gas). See: Esser, A., Sensfuss, F., Final report: \textit{Evaluation of primary energy factor calculation options for electricity, Fraunhofer ISI for the EC}, 13.5.2016.

\textsuperscript{15} Methanation is the conversion of COx to methane (CH\textsubscript{4}) using hydrogen (and a Ni-catalyst). For instance: CO\textsubscript{2}+4H\textsubscript{2} \rightarrow CH\textsubscript{4} + 2H\textsubscript{2}O +heat. The reaction is exothermic. The methanation is called ‘carbon-neutral’ because in the production process of the methane CO2 is absorbed (but still some CCS is required to be really ‘neutral’).

\textsuperscript{16} Carbon Capture and Utilisation. Compared to CCS (Carbon Capture and Storage) techniques it has the advantage of no risk of leakage and certain techniques can be pre-conversion, meaning that the
mixed in with the natural gas in an ever increasing share. The R/P ratio (Reserves vs. Production) of natural gas reserves is currently 55 year and likely to be increasing because of newly available shale gas, etc.. And there are strong market forces in the EU’s most important suppliers (Norway, NL, UK, Russia\textsuperscript{19}, Algeria, Qatar) to decarbonise the gas before distributing it in the form of hydrogen.

There is a problem with this scenario and this is where Ecodesign could come in: Below 30% share of hydrogen a normal natural gas boiler could work, but at a higher shares special adaptations are needed –beyond a simple switch of burner bed and a nozzle—to enable safe and optimal hydrogen combustion. This is what is intended by ‘hydrogen-ready’, which is a boiler that can operate on both natural and a high (>30%) share of hydrogen gas. At some point, i.e. when switching to 100% hydrogen, some further adjustment of the burner bed might be needed. Without the gas boiler being ‘hydrogen ready’, the whole boiler needs to be replaced. This means a stranded investment of potentially several thousands of euros per household if and when such a switch to hydrogen is needed, e.g.. Socially and politically, even if a sustainable climate of the planet is at stake, this will be a very difficult message to sell to the citizens. To avoid such a situation, and given the product life of heating appliances that is now around 20 years or more, the promotion and –eventually—making it mandatory to require hydrogen-readiness is paramount.

In this context it is important to realize that only 100% (carbon-free) hydrogen gives carbon-neutrality. Mixing in up to 30% hydrogen in the gas grid helps in the transition phase, but if it stops there then the Paris goals will not be achieved.


\textsuperscript{18} Pyrolysis of methane (CH4) without oxygen gives solid carbon C and hydrogen gas 2H\textsubscript{2}. Around 1/3 molecule of hydrogen can be used for the pyrolysis and 5/3 molecule of H2 is the effective output for further use. The solid carbon could be used e.g. as carbon black. See: Abanades A, et al., 2015. Also (more popular): https://www.advancedsciencenews.com/decarbonizing-natural-gas-methane-fuel-without-carbon-dioxide/

The low efficiency of hydrogen conversion is often mentioned as a negative, but most estimates start from the assumption that the hydrogen from wind- or solar driven electrolysis (efficiency 75%) first needs to be stored (at very high pressure, e.g. 700 bar or thereabouts, to minimise storage volume) and converted again to electricity by a fuel cell (efficiency 50-60%) when there is not enough variable (solar, wind) renewable electricity. In that case, the efficiency of the process may be lower than Joule-heating (40%) and the costs for a single household may be extremely high.

But the most advantageous heating appliance would be a hybrid of an electric heat pump and a hydrogen-fired boiler back-up. This gives the required energy flexibility (no actual storage, just a switch), it is cheap for the householder (no fuel cell; basically known technology with some minor adjustments; no stakeholder contended the 200-300 euro extra costs!). With a hybrid you don’t need the local storage tank –storage may be at the distributors—and you don’t need the fuel cell.

Hydrogen boilers exist, as a redesign of a natural gas boiler, in experimental projects and—as mentioned and confirmed by the comments of BDR Thermea. In that context it is much more likely that hydrogen will be used for space heating and certain industrial applications than for cars. Hydrogen cars require high pressure storage tanks and—because electricity is much more efficient for traction than for combustion—a fuel cell. So, for cars it is much more efficient to directly use the electricity from charging batteries.

(Reprinted from: SINTEF & IFPEN (forthcoming, 2019). Hydrogen for Europe pre-study report)

Figure 2. Illustration of a qualitative scenario for future production of hydrogen from natural gas, electricity from renewables and biomass

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20 BDR Thermea made these hydrogen boilers. They do correct the KIWA-report, used as a source in Task 6, that indeed a larger fan would not be required but that it is enough to regulate the air-side of the premix. Most adaptations are in sensors and controls.

21 For trucks, trains, planes it might be advantageous to use hydrogen, but that requires a considerably smaller amount of hydrogen.

Eurofuel mentions several publications related to low-carbon or carbon-neutral solutions. Biomass-to-Liquid (BtL) and Power-to-Liquid (PtL) solutions based on CCS. The BtL-solutions are believed to be the most relevant and are discussed in the next section.

**Response:** Most PtL-solutions are based on calculated carbon-neutrality, i.e. a carbon credit is acquired because of CO2-absorption in production and used to compensate the carbon release during use (e.g. combustion).\(^2\) This is not the same as green hydrogen or pre-conversion decarbonisation of natural gas. Also a switch from fossil gas oil to these solutions does not necessarily require a replacement of the boiler. In other words, it is doubtful if Ecodesign or similar measures should play a role.

### 2.3 Biogas

Apart from hydrogen there are fuels that are not carbon-free during combustion, but carbon-neutral taking into account their credit as carbon-sinks and taking into account that their combustion avoids a much more damaging impact on the climate.

The general idea is that these ‘biofuels’ originate from plants and during their previous life as plants they will have taken —through photosynthesis under the influence of (sun)light— ‘carbon’ (CO\(_2\)) and water out of the atmosphere, giving sugars to the plant and oxygen back into the ambient. Another concept is the fact that by capturing biogas, i.e. the gas from anaerobic digestion or fermentation of organic waste, one avoids the release of a gas that is 25-times more powerful greenhouse gas than CO\(_2\). And if that captured gas is then combusted, releasing CO\(_2\), the overall carbon balance is still positive.\(^2\)

Having said that, the balance is fragile. For instance, if the biofuel is transported halfway around the world, e.g. from the US or Latin-America to Europe, a considerable part of the positive carbon-balance is destroyed because of the carbon emissions of transport.

There is the issue of energy crops: vegetal oil crops (colza, palm seeds) grown specifically to substitute diesel or sugar cane grown to make methanol replacing petrol. Sometimes valuable rain forests, important carbon-sinks, are destroyed to make way for energy crops. Sometimes (monocultures of) energy crops take the place of food crops in areas where there is food-shortage.

Most of these issues relate to oil-substitutes or solid biofuels. Biogas, usual from fermentation of organic (food-related) waste and/or manure, is typically a local energy source and there is no substitution of food crops.

The European association of gas utilities Eurogas calls the mix of renewable gases ‘R-gas’ and believes it can make up 76% of the gas used in 2050.\(^2\) Eurogas also asked PRIMES

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\(^2\) The exceptions are ammonia and methanol from green hydrogen, both fuels that are not used for space heating.

\(^2\) Bio-methane originates from all organic matter in nature like leaves, dead plants and animals, most part of faeces, etc., but if we can capture the part that is anthropogenic (man-made, e.g. originates from elements in the human food-chain) this is already a Good Thing.

in 2016 to calculate a gas scenario that definitely show large technical and economic advantages vis-à-vis the full electrification scenario.

In the review clauses of the water heater regulations there is the question on the appropriateness to set Ecodesign requirements for biomass-based gas- or liquid fuel fired water heaters. To answer that question, it must first be established whether such water heaters can technically be distinguished from normal natural gas or oil-fired water heaters. This question was put by the study team to the ECO-BEDAC committee with experts from the water heater sector. The answer was that although biogases or bio-oil may contain aggressive substances/pollutants that attack certain seals in the water heater these problems can be solved by using other/improved materials or designs. Water heaters suitable for bio-oil (FAME - Fatty Acid Methyl Ester or Biodiesel, usually a 10% share FAME is allowed) or bio-gas can be distinguished from other water heaters by a fit-for-purpose indicator (indicated in technical specifications). What could be more serious is the wide range of calorific values that may occur with biogas. A transitional solution may be that, as it is done today, the biogas is mixed with natural gas to stay within a limited range of calorific values. Or, and in that case an adapted design is necessary, the water heater is equipped to handle a wide range of calorific values, possibly at the expense of a more limited modulation.

A design option is to give a special energy efficiency allowance, e.g. 20%, for water heaters that are placed on the market exclusively to handle biogas. But a specific definition is then needed to differentiate them from fossil fuel fired boilers. To completely exempt these water heaters, as is current practice, does not seem advisable, in order not to create a loophole e.g. whereby large quantities of non-compliant natural gas water heaters are sold as ‘biogas water heaters’.

Another issue is the NO\textsubscript{x}-emission of biofuel water heaters, where currently there is no yardstick for what is feasible.

**Stakeholder comments**

Marcogaz mentions that the draft report does not acknowledge the development of biomethane in several Member states, i.e. biogas upgraded to natural gas quality, able to be injected in natural gas grids or to be used as a fuel for vehicles. In Sweden, Finland, the United Kingdom, the Netherlands, Denmark, the share of biomethane is above 14-15% of gas production. Denmark has already reached a level where 10% of the gas in the grid is bio methane (annual average). France has a goal of 10% biomethane in gas grids by 2030. The future impact of H\textsubscript{2} injection in gas grids should also be taken into consideration. The European Commission’s involvement in supporting the development of hydrogen on the road to a climate neutral economy can be witnessed through FCH JU (public/private partnership used by the EC for financing R&D and demonstration projects for the development of fuel cells and hydrogen). Among the calls published by FCH JU in 2019 one deals with the impact on gas grids, and another one on the impact on end-use applications (gas appliances).

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27 Only if directly relatable to biogas. If due to ongoing and future gas quality variations because of other reasons (LNG terminals, Russian gas, Groningen field depleted) then no allowance because “business-as-usual”.
Eurofuel reminds the study team that liquid biomass (‘biodiesel’) should not be forgotten and points to various studies that especially highlight the economic potential of biodiesel for Germany. The studies discuss the technologies, the economic potential (e.g. of electrolysers), etc..

On the other hand, the sustainability and carbon-impact of biodiesel, especially from vegetable oil is fiercely debated. Green group Transport & Environment mentions continuous growth of palm oil imports, two-thirds of which goes to non-food applications such as heating oil.\textsuperscript{28} \textsuperscript{29} The impact is on indirect and direct Land Use Change (ILUC, DLUC), which ultimately translates into greenhouse gas (‘carbon’) emissions, as is shown in Figure 3 below.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure3.png}
\caption{Overview of modelling results: LUC emissions per scenario. Source GLOBIOM 2015.}
\end{figure}

\textbf{Response:} As mentioned before, for solid biomass boilers a Biomass Labelling Factor (BLF) of 1.45 applies. It thus stands to reason that also a similar factor would apply to gaseous or liquid biomass. However, with straw-, wood log- or pellets-fired boilers the

\textsuperscript{28} Transport & Environment, The trend worsens: More palm oil for energy, less for food. Drivers burn more than half of palm oil imported into the EU, briefing, June 2019.

\textsuperscript{29} IIASA, Ecofys et al., The land use change impact of biofuels consumed in the EU, Quantification of area and greenhouse gas impacts, report to the Commission, 27.8.2015.
product design is usually evidently different from a fossil solid fuel (coal) fired boiler and thus there is no (or little) danger of creating a loophole when applying the BLF. In the case of boilers for gaseous or liquid biomass such risk could exist. That is why Task 6 is proposing a labelling factor only where the boiler is clearly designed for that purpose. And it is believed that this is the case when the boiler is prepared for 100% biogas or bio-oil, i.e. able to handle a wide range of calorific values and withstand aggressive fractions (such as hydrogen sulphide, siloxanes, moisture) that can be found in 100% biogas or bio-oil (traditional oil carrying seal materials may need to be modified, bio-oil also often has a higher viscosity).

It is important to realise that it is not within the scope of Ecodesign legislation to define a pef (primary energy factor) or similar for a situation with a significant mix-in of biogas (or hydrogen) in the public gas. It is understandable that this is an important subject for gas utilities and gas appliance industry, but the decision on the new pef for electricity was taken at the level of a triilogue between European Commission, Council and Parliament and not put forward by a contractor in a specific Ecodesign review study. The same goes for liquid biomass, where there is the added dimension – compared to biogas from fermentation— of land-use for energy crops.

Germany (UBA-BAM) mentions that the loophole of biogas boilers should be closed. If space heaters are operable with conventional gas, they should meet the Ecodesign requirements for the operation with conventional gas. The actual use of a product cannot be predicted when placing it on the market. However, we do not think that biogas space heaters should be subject to Ecodesign when operated with biogas. The quality of biogas depends on the raw material (substrate) and the art of processing. Its composition is always different. Testing of biogas combustion at the test stand can only show emissions using a standard fuel composition but not real emissions. Testing of biogas makes only sense in local case by case examination. This cannot be solved by Ecodesign. A 10-percentage efficiency bonus is also not an appropriate solution, according to UBA-BAM.

Response: UBA-BAM is apparently in favour of keeping the current exemption for biogas boilers from the scope. Although this has so far not led to loopholes that the study team is aware of, loopholes could occur in the future because there is no technical definition or test defining a biogas boiler. In other words, it is possible to try to keep an inefficient boiler on the market by claiming it is a biogas boiler. Secondly, keeping a real biogas boiler out of the scope, with a favourable rating, also means a missed opportunity in promoting such a device. It also does not seem consistent vis-à-vis the practice with regulating solid biomass boilers. We would agree that specifying suitable tests to differentiate the biogas boilers from others requires a substantial effort and — later on— surveillance effort. Thus, in the end, the policy makers will have to decide whether it is worth it given the relatively modest contribution that 100%-biogas boilers can make to decarbonisation.
2.4 Primary energy factor

One of the questions in the review clause is to check the appropriateness of the Conversion Coefficient (CC), which in practice is synonymous to the primary energy factor (pef) for electricity generation and distribution. The decision on this issue has a bearing, not just on Ecodesign regulations but also on the Energy Efficiency Directive, and it has recently been decided at the level of a triilogue between Council, Parliament and Commission to change the pef from 2.5 to 2.1. This reflects the EU policy as described in preamble (40) of the recast of the EED (Directive 2018/2002):

(40) Reflecting technological progress and the growing share of renewable energy sources in the electricity generation sector, the default coefficient for savings in kWh electricity should be reviewed in order to reflect changes in the primary energy factor (PEF) for electricity. Calculations reflecting the energy mix of the PEF for electricity are based on annual average values. The 'physical energy content' accounting method is used for nuclear electricity and heat generation and the 'technical conversion efficiency' method is used for electricity and heat generation from fossil fuels and biomass. For non-combustible renewable energy, the method is the direct equivalent based on the 'total primary energy' approach. To calculate the primary energy share for electricity in cogeneration, the method set out in Annex II to Directive 2012/27/EU is applied. An average rather than a marginal market position is used. Conversion efficiencies are assumed to be 100% for non-combustible renewables, 10% for geothermal power stations and 33% for nuclear power stations. The calculation of total efficiency for cogeneration is based on the most recent data from Eurostat. As for system boundaries, the PEF is 1 for all energy sources. The PEF value refers to 2018 and is based on data interpolated from the most recent version of the PRIMES Reference Scenario for 2015 and 2020 and adjusted with Eurostat data until 2016. The analysis covers the Member States and Norway. The dataset for Norway is based on the European Network of Transmission System Operators for Electricity data.

The recast EED 2018/2002/EU also draws a direct line between the use of the (revised) PEF and its effect on Ecodesign and energy labelling measures by requesting a revision of this coefficient by December 2022 and every four years after. This revision shall be carried out taking into account its effects on other Union law such as Ecodesign Directive 2009/125/EC and Labelling Regulation (EU) 2017/1369 (Annex IV, footnote 3, as amended by 2018/2002/EU). It is therefore decided by the Union that the effects of a change in pef on ecodesign and labelling is addressed by studies in the context of Directives 2018/2002 and 2012/27.

The change of the pef has consequences for all issues where the pef implicitly or explicitly plays a role in the legislation, i.e. for all conversions from electricity to primary energy in determining the (seasonal) efficiency, e.g. for electric heat pumps, electric resistance heaters and auxiliary components, but also for certain class limits that were set on the assumption that the theoretical maximum primary energy efficiency (from electricity) was 40% (CC = 2.5). With the new Energy Efficiency Directive 2018/2002 this becomes 47.6% (CC = 2.1). But also, for electric heat pumps it is not intended that the energy efficiency limits should become more lenient. An exact conversion is not possible but a slightly more ambitious limit for XXL and 3XL/4XL tapping patterns was assumed.

Table 2 shows the current and pef-corrected Ecodesign minimum limits that were presented at the 2nd stakeholder meeting. For appliances where the limits are based on full-electric energy consumption, i.e. for all classes up to and including XXL, the correction-factor (2.5/2.1) is applied.
Table 2. Ecodesign minimum energy efficiency limits, current and pef-corrected

<table>
<thead>
<tr>
<th>Water heating energy efficiency per tapping profile</th>
<th>NOW</th>
<th>NEW</th>
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</thead>
<tbody>
<tr>
<td>3XS-XXS-XS-S tapping profiles</td>
<td>32%</td>
<td>38%</td>
</tr>
<tr>
<td>M tapping profile</td>
<td>36%</td>
<td>43%</td>
</tr>
<tr>
<td>L tapping profile</td>
<td>37%</td>
<td>44%</td>
</tr>
<tr>
<td>XL tapping profile</td>
<td>38%</td>
<td>45%</td>
</tr>
<tr>
<td>XXL tapping profile</td>
<td>60%</td>
<td>61%</td>
</tr>
<tr>
<td>3XL-4XL tapping profiles</td>
<td>64%</td>
<td>65%</td>
</tr>
</tbody>
</table>

Following the stakeholder comments hereafter, these limits were differentiated by technologies and the theoretical limit of 47.6% is then only relevant for electric (Joule effect) water heaters (See Table 3).

For special cases where water heaters are using carbon-neutral gaseous or liquid energy sources like biogas, e-hydrogen and —if appropriate— other e-fuels, it is proposed to apply a labelling factor 1.2 to the seasonal efficiency similar in effect to the pef-correction (2.1/2.5). This aims at a higher label rating, e.g. A+, setting them apart from the fossil fuel versions.

**Stakeholder comments**

Sweden, without counterarguments from others at the 2nd stakeholder meeting in May 2019, pleaded again—while maintaining the current energy labelling principle of one scale—to have at least a technology-specific Ecodesign regulation for (dedicated) water heaters. This would enable the policymakers to raise the overall ambition level by tackling specific types. It would also, according to Sweden, make it superfluous to take certain explicit actions like banning the pilot flame because the more specific limits would do that implicitly and allow a specific solution for TDHPs at least for Ecodesign requirements. The technology subdivision should be more specific than just between gas- and electric water heaters, as investigated in the 2016 special review study, but at the same level as the technology-specific Ecodesign regulation for space heaters. Norway supported this plea, because the current regulation for XXL, 3XL and 4XL phases out the placing on the market of complete electric storage water heating units (ESWHs) that use the Joule effect (resistance heaters). This is the dominant water heater type in Norway, because of its particular energy mix with hydropower. Furthermore, Norway presented its case that ESWHs can be an effective means of energy storage during the stakeholder meeting (see also the project website).

**Response:** In the 2007-2013 period there were good reasons to follow a technology-neutral, strictly functional approach in saving primary energy, using the newly found consensus on tapping patterns after 20 years of preparation. With space heating this was not possible, because of the considerable differences in metrics and testing procedures, e.g. between heat pumps boilers and fossil fuel fired central space heating boilers. At the moment there are still good reasons to follow the strictly functional approach and it is a good thing that the proposal by Sweden and Norway still maintains the energy labelling metrics to show consumers the actual primary energy savings across technologies. On the other hand, there are new policy goals relating to fighting climate change and reducing carbon emissions.

And, while from the primary energy viewpoint it is detrimental to use such a high-exergy energy source as electricity for low-exergy applications as water heating, there is a
widespread belief that renewable ‘electrification’ will be an important part of the answer. In view of this, the study team has prepared a preliminary technology-specific set of Ecodesign efficiency limits for dedicated and combi water heaters, based on what could be estimated –given the limited time– the Least Life Cycle Cost solution with each of the technological categories discussed in Tasks 2 and 4. Task 2 gives a detailed breakdown of the acquisition costs (installation and product price) and the running costs for the different types, sizes and technologies of water heaters. In Task 4 average Life Cycle Costs are calculated for all categories and sizes. Also task 4 discusses new products and specific design options for the various dedicated water heaters; this information was used qualitatively to make an estimate of appropriate minimum energy efficiency limits in Table 3. Supplementary information can be found in the notes of Table 3 below. In the follow-up these preliminary new limit values will have to be discussed with stakeholders.

The table below gives the preliminary set of new limit values, with some explanation in the notes.

Table 3. Proposed Ecodesign new minimum energy efficiency limits for water heaters, combi and dedicated
(source: preliminary estimate of LLCC by VHK, July 2019)

<table>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>3XS-XXS-XS-S tapping profiles</td>
<td>42%</td>
<td>38%</td>
<td>55%</td>
<td>45%</td>
<td>45%</td>
<td>72%</td>
<td>60%</td>
<td>51%</td>
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<tr>
<td>M tapping profile</td>
<td>45%</td>
<td>43%</td>
<td>75%</td>
<td>56%</td>
<td>56%</td>
<td>75%</td>
<td>105%</td>
<td>88%</td>
</tr>
<tr>
<td>L tapping profile</td>
<td>45%</td>
<td>44%</td>
<td>80%</td>
<td>67%</td>
<td>68%</td>
<td>82%</td>
<td>114%</td>
<td>96%</td>
</tr>
<tr>
<td>XL tapping profile</td>
<td>45%</td>
<td>45%</td>
<td>85%</td>
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<td>78%</td>
<td>90%</td>
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<td>X XXL tapping profile</td>
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<td>89%</td>
<td>83%</td>
<td>100%</td>
<td>110%</td>
<td>148%</td>
<td>124%</td>
</tr>
<tr>
<td>3XL-4XL</td>
<td>45%</td>
<td>45%</td>
<td>92%</td>
<td>88%</td>
<td>105%</td>
<td>115%</td>
<td>157%</td>
<td>132%</td>
</tr>
</tbody>
</table>

Notes:
[1]: For oil-fired versions of the GIW, GSWH and COMBI, multiply the limit values by 0.95
[2]: Limits are close to maximum for electronic EIW, at pef=2.1, according to catalogue values.
[3]: Limits for 3XS-XL derived from pef-corrected current regulation. For XXL/3XL/4XL they are close to maximum.
[4]: Own assessment. Limits will eliminate (indirectly) pilot flame use as requested.
[5]: Based on best catalogue data (AO Smith)
[6]: Limits also apply to gas-fired heat pumps (A7/W55) as well as fossil fuel boilers with external indirect cylinder. Limits derived from instant-combi minus storage standing losses
[7]: XL-limit assumes integrated instantaneous PFHRD. XXL/3XL/4XL limits assume integrated storage PFHRD (<3l). Example: Intergas Xtreme 36 (XXL, 115% on GCV)
[8]: Limits based on A7/W55 EN16147. Values derived from catalogue data (mainly Ariston). The S-class value is based on a corrected (downward) value that could be realised by a variation on the Lydos hybrid (currently M with 90% efficiency). Limits also apply to electric heat pumps with indirect cylinder (A7/W55).
[9]: HPWH-limits corrected for the difference in pef, using a factor (2,1/2,5). See text hereafter. Also to discuss in a follow-up if this is subject to H2-ready or biogas TDHPs only or broader. So very preliminary addition to be treated with caution.

Stakeholders were not in favour of applying a 1.2 labelling factor for H2-ready, mainly because it would be misleading the consumers that the efficiency of such a water heater would be higher. (see also more extended version of stakeholder comments with paragraphs 2.2 and 2.3). At best, supported by Germany and ECOS-EEB, there could be an icon on the label saying that the appliance would be ready for H2 or biogas.

Response: Such a labelling factor would not be more ‘misleading’ than the LBF or possibly an overoptimistic pef for electricity generation. Anyway, it is clear that it is too early in the political process to make such a decision, one way or the other. It is proposed to have more discussions and study on the subject in a follow-up. Possibly, a
factor could also be decided at a later stage through an external act, e.g. comparable to the pef for electricity.

Most stakeholders could see the logic of adapting the Ecodesign limits of the water heaters to the new pef. The only exception is that it is no longer fair to the thermally driven (gas/oil) heat pumps (TDHP) to have only one limit for heat pumps, according to EHI, the TDHP-section of EHPA and Eurogas. For electric heat pumps the pef-correction should apply (130% HT and 150% LT) but for TDHP, i.e. heat pumps that did not profit from the pef-corrected CC factor, the current limits should be maintained.

Response: This seems reasonable and will be recommended for the follow-up.

Labelling classes
To maintain the same ambition level, the energy labelling classes relating to electric water heaters will have to be adjusted to account for the new conversion coefficient (CC) of 2.1 instead of 2.5 (factor 1.19).

For the water heating efficiency of dedicated water heaters (and combi water heaters in Lot 1) there is the correction for the new CC of 2.1 instead of 2.5, indicated by green cells in Table 4 hereafter). In principle, this correction can be applied to all current class limits of 40% or lower, that are still allowed under the current Ecodesign limits (green cells in Table 4).

Furthermore, the solar industry signals that in Southern Europe they have competition from low-cost, small gas-fired instantaneous heaters that have an “A+” label without any renewable energy, whereas they struggle to get an “A+” label with a solar installation. In other words, the label values for XS and S gas instantaneous appear too lenient and thus it is proposed to skip an energy class there (pink cells in Table 4).

Due to Ecodesign measures the lowest energy classes (yellow cells in Table 4) are now empty and can be eliminated. However, contrary to space heaters, there is no urgent need for extra energy classes. Therefore, there is no need to impact the market and manufacturers with the administrative and commercial burden of a shift in label ratings for the same product at this stage (except for the XS and S class).

Table 4. Water heater, lower Energy Label class limits NOW and NEWly proposed

<table>
<thead>
<tr>
<th>NOW water efficiency (in %) lower limit</th>
<th>NEW water efficiency (in %) lower limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class</td>
<td>3XS</td>
</tr>
<tr>
<td>A+++</td>
<td>62</td>
</tr>
<tr>
<td>A++</td>
<td>53</td>
</tr>
<tr>
<td>A+</td>
<td>44</td>
</tr>
<tr>
<td>A</td>
<td>35</td>
</tr>
<tr>
<td>B</td>
<td>32</td>
</tr>
<tr>
<td>C</td>
<td>29</td>
</tr>
<tr>
<td>D</td>
<td>26</td>
</tr>
<tr>
<td>E</td>
<td>22</td>
</tr>
<tr>
<td>F</td>
<td>19</td>
</tr>
</tbody>
</table>
The new class limits for A+/A++/A+++ for the newly proposed tapping patterns XS and S are more stringent than today, because in some countries (Portugal, Spain, Italy) there was an unfair competition between low-cost GIWHs, that could easily achieve a 44% efficiency—and thus an energy rating ‘A+’—and a solar collector that is renewable and costs 5 to 10 times as much but often could not achieve ‘A+’. See also the Task 1 report.

**Stakeholder comments**

**ANEC/BEUC** agrees to align EL classes and ED limits if possible. APPLiA points out undesired rounding effects of changing the pef from 2.5 to 2.1, especially for ESWHs. JRAIA supports the change of pef, asks reasons for the exemptions in Table 2 and Table 3, and asks for a sufficient transition period.

**COGEN, BDR Thermea** and more cogenerator stakeholders are arguing for a complete review of the PEF towards the marginal PEF. As explained before, it is outside our mandate to ‘correct’ the trialogue-results of European Commission, Council and Parliament.

**EHPA** points out that the PEF also applies to (limits for) dedicated heat pump water heaters.

**ECOS-EEB** would like the energy label for air source heat pump water heaters (also HPWHs) to include efficiencies for all 3 climate zones. Currently only tested at +7 ºC outdoor temperature, they should be tested also at -2 ºC (cold) and +20 ºC (warm). SPIUG mentions that a product fiche should also be mandatory for LT heat pumps (35 ºC).

**UBA-BAM** (Germany) is in favour of recalculating classes due to changes in the pef and showing the efficiency figure as well as electrical output and efficiency of mCHP units. UBA-BAM sees the need, especially towards installers, for further differentiation in upper energy classes to promote renewables. Asks the study to elaborate if the impact of the label could be improved, because there is no classic shopping situation, by showing the available class range and the product label in the offer. Sees only 6 labelling classes for water heaters and asks to assess if there is the need for further distinction in 7 classes.

**BDR Thermea** comments on par. 2.4: Mentions that the PEF is in NCV and the ED & EL heating efficiency relates to GCV, so the PEF=2.1 should be adapted.

Response: The new PEF=2.1 and old PEF=2.5 (ESD 2006/32/EC, OJ L 114, 27.4.2006, p. 64–85) both use NCV, so for electricity a correction 2.5/2.1 is correct. For fossil fuel there is no conversion.

Mentions that the marginal electricity saving should be applied (2.9) and not the average (2.1).

Response: The decision to take the average electricity saving has been taken at the level of trialogue between European Council, Parliament and Commission, also based on a preparation with extensive stakeholder consultation (2 CFs 2014 and 2016) and a 2016 Fraunhofer ISI study on the subject. It is not up to the study team to re-iterate that decision.

Reasoning with Carnot efficiency (2.5) is highly debatable/misleading, but the outcome is moving in the right direction (marginal electricity).

Response: As mentioned above; the decision has been taken at the highest level and it is not up to explicitly change that decision. The proposed factor 2.65 (2.5 + 1.06 for avoided distribution losses), decoupled from PEF, is a pragmatic solution which we
believe is still (just) within the domain of the ED and EL legislation, i.e. a solution that keeps promoting efficient mCHP also in the future.

Finally, BDR Thermea is opposed to mentioning the electrical efficiency on the mCHP label, because it is a heating label that should be comparable in that sense.

Response: It is not unusual to include relevant performance information, like the production of electricity by the product at hand, on the energy label.

As documented in the minutes of the stakeholder meeting, there was a discussion on whether ‘rescaling’ was allowed for (boilers and) water heaters under the rules of the new (2017) Energy Label Regulation. In particular, EHI and some individual manufacturers were under the impression that nothing could be changed about the classes and class limits of the current energy label until 2026. Bosch TT and others brought forward that having no longer an ‘A’ rating for condensing boilers would be counter-productive because there is still a considerable saving potential in promoting condensing (gas/oil) boiler technology. On the other hand, there were Member States (e.g. Germany) and manufacturers (e.g. Viessmann) that were in favour.

Response: The study team has the mandate, following the review clauses of the regulations, to look into –amongst others— technological progress and prepare proposals to update the legislation accordingly. The fact that boilers and water heaters were exempted from the obligation for other product groups to eliminate the ‘+’ classes, does not mean that there can be no change and it does not diminish the mandate for the study team. In fact, a member of the Green party in the European Parliament, present at the 2nd stakeholder meeting, reminded the audience of the goal to eliminate the ‘+’ classes if possible.

Having said all that, the timing of the measures also plays a role. If the implementation date for a new labelling scheme comes closer to the year 2026, policy makers may decide to prolong the current scheme until that date.

### 2.5 Verification tolerances

As mentioned in Task 1, a group of laboratories is currently engaged in a broad Round Robin Test (RRT) project covering test repeatability and reproducibility of most types of water heaters. The final and complete results of this two-year ECOTest project will be published in the early fall of 2019. The ECOTest outcomes relate to:

- The results and quantitative evaluation of repeatability and reproducibility of the Round Robin Tests according to the current test standard.
- Following the experience of the RRTs and expert opinion, recommendations for standards, legislators and accreditation entities on how to increase repeatability and reproducibility.

These will be discussed in the following two subsections. Furthermore, the ECOTest project did not include a new round of testing to find out what verification tolerances could be achieved with improved standards. For that reason, the study team requested laboratories –on a personal title– to give their expert opinion of the level of verification tolerances that they believe will achievable with better standards.
ECOtest Round Robin Test results

The tables hereafter give the findings from RRTs in the ECOtest project. The values represent the outcomes of the Round Robin Test per Working Package, corrected for evident errors and without stragglers or outliers.\(^\text{30}\)

The columns in the table— from left to right — give the

- name of the tested parameter (measurement unit in brackets),
- median of test results,
- average of test results,
- standard deviation of the repeatability \(sr\) (in %),
- standard deviation of the reproducibility \(sR\) (in %)
- difference between the lowest and highest average values \(minmax\) (in %),
- ratio of \(minmax\) and the average of the test results (in %)
- number of test results included \(N\) test labs (#)

In the Annex II extended tables are given, showing an alternative calculation method for the reproducibility by multiplying the standard deviation by 2.83 and 4.00 (R1 and R2 absolute values respectively) and subsequently calculate them as percentage of the average (R1 and R2 averages). It also shows status and data processing by the labs.

The ECOtest team-leaders point out that, while the results in the tables below can be regarded as ‘draft final’ and can be the quantitative basis for the discussion on verification tolerances,

1. There might be (a few) results with some data that are not yet consolidated. In that case, no definitive conclusions can be drawn.
2. Some of the data would apply in the conditions that the standards are improved according to suggestions made in the project.
3. The relative variation Max-Min and Reproducibility are relevant to compare with the actual tolerance when keeping in mind that the RRT will vary in time with appliances tested, labs involved and possible changes in the test methods.
4. Differences between test results can have several reasons linked to three main sources: the laboratories, the appliance and the test method.

\(^{30}\) The number of stragglers and outliers can be derived from the last column, i.e. where the number of test labs for a specific parameter is less than the total number of test labs in the Work Package. Outliers and stragglers are extreme values, evaluated in this case by means of Mandel’s statistics, whereby outliers are observations greater than the critical value at 1% confidence level and stragglers are observations greater than the critical value at 5% confidence level and less or equal to the critical value at 1% confidence level.
Table 5. ECOtest preliminary results Round Robin Tests (RRTs), dedicated Water Heaters
(source: misc. draft Ecotest Work Package reports, Mar. 2019; summary by VHK study team)

<table>
<thead>
<tr>
<th>RRT2 extension WP3 (11 labs)</th>
<th>Storage water heater, 111 L, gas fired 8 kW (Hi), L tapping pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>median</td>
</tr>
<tr>
<td>40°C mix water (L)</td>
<td>216.9</td>
</tr>
<tr>
<td>Annual Fuel Cons. AFC (GJ GCV)</td>
<td>14.99</td>
</tr>
<tr>
<td>eta seasonal WH (%)</td>
<td>61.06</td>
</tr>
<tr>
<td>Gas cons Qfuel (kWh)</td>
<td>21.21</td>
</tr>
</tbody>
</table>

WP7 (8 labs) RRT3

|                               | median | average | Sr  | sR   | minmax | minmax/avg | N-test labs |
| eta water heat (%)            | 138.70 | 138.77  | 1.97| 4.97 | 4%     | 7           |             |
| COP DHW                       | 3.38   | 3.35    | 0.08| 0.22 | 6%     | 8           |             |
| Annual Energy Cons. AEC (kWh/a)|1207.74| 1208.24 |17.71| 43.29| 4%     | 7           |             |
| V40 litres equivalent at 40°C (L)|406.23| 403.51 | 7.72| 23.20| 6%     | 7           |             |
| Reference DHW temperature (°C)|53.09  | 53.15   | 0.35| 1.03 | 2%     | 7           |             |
| Rated power (kW)              | 1.50   | 1.50    | 0.04| 0.12 | 8%     | 7           |             |
| Useful energy DHW (kWh/tap pattern)|19.19| 19.22  | 0.16| 0.46 | 2.39%   | 8           |             |
| Elec. Cons during tapping (kWh/tap pat) | 5.69 | 5.63  | 0.32| 1.01 | 17.94%  | 8           |             |
| Standby power (W)             | 26.06  | 26.15   | 2.12| 6.28 | 24.02%  | 8           |             |
| Elec cons heat up of store (kWh)|4.08 | 4.1    | 0.1 | 0.3  | 7.32%   | 8           |             |

Last 4 rows are from preliminary results (not consolidated)

Because they may be relevant for the verification tolerances on standing heat losses, the table below also gives specifics of the solar (combi) store that were tested in WP8.

Table 6. Solar store in WP8

<table>
<thead>
<tr>
<th>WP8 (3 labs) RRT2</th>
<th>Solar store, 400 L, bivalent ('hot-top')</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>median</td>
</tr>
<tr>
<td>Nominal volume (L)</td>
<td>404</td>
</tr>
<tr>
<td>Effective volume (L)</td>
<td>401</td>
</tr>
<tr>
<td>Auxiliary heated volume (L)</td>
<td>125</td>
</tr>
<tr>
<td>Standby heat loss UA (W/K)</td>
<td>2.68</td>
</tr>
<tr>
<td>Heat transfer cap solar to store</td>
<td>473.62</td>
</tr>
<tr>
<td>Heat transfer cap aux to store</td>
<td>388.88</td>
</tr>
<tr>
<td>Standing loss S @Ts=65, Ta=20°C</td>
<td>120.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WP8 (3 labs) RRT3</th>
<th>Solar combi store, 825 L, bivalent (EN 12977-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>median</td>
</tr>
<tr>
<td>Nominal volume (L)</td>
<td>825</td>
</tr>
<tr>
<td>Effective volume (L)</td>
<td>794</td>
</tr>
<tr>
<td>Auxiliary heated volume (L)</td>
<td>334</td>
</tr>
<tr>
<td>Standby heat loss UA (W/K)</td>
<td>3.44</td>
</tr>
<tr>
<td>Heat transfer cap solar to store</td>
<td>1199.9</td>
</tr>
<tr>
<td>Heat transfer cap aux to store</td>
<td>2082</td>
</tr>
<tr>
<td>Effective thermal cap (kJ/K)</td>
<td>3285</td>
</tr>
<tr>
<td>Standing loss S @Ts=65, Ta=20°C</td>
<td>154.9</td>
</tr>
</tbody>
</table>
ECOtest recommendations for improvement of the standards
During and after the RRTs the laboratories brainstormed about ways to improve repeatability and reproducibility in the standards, the legislation and the accreditation procedure. It would be out of the scope of this preparatory Ecodesign review study to sketch all recommendations in detail, especially because the full ECOtest report is expected to be approved and thus publicly available within a matter of months (Sept./Oct. 2019).

Below are the pictures of a few test rigs.

Figure 4. Left: Gas-fired water heater (WP3); Right: Dedicated heat pump water heater (HPWH, WP7 RRT3)

Figure 5. Left: SHW solar store 400 L (WP8, RRT2); Right: Solar combi store 825 L (WP8, RRT3)
The ECOtest project’s budget did not allow for re-testing after improving the standards. Therefore, outside the ECOtest project, some laboratories were prepared to state their expectations how the verification tolerances would improve with better test standards.

For instantaneous and storage gas-fired water heaters the minmax/avg efficiency values are 5% and 13% respectively. Today, it would be possible to use 8% (instantaneous) and 15% (storage type). After improvements, i.e. in 2021, 4-5% (instantaneous) and 6-8% (storage type) verification tolerances should be possible.

For the dedicated heat pump water heater (WP7, RRT3), CETIAT and Fraunhofer ISE recommend investigation on a broader basis needed in order to make conclusions. Having said that, the minmax/avg value of the water heating efficiency of the RRT3 is 6% (without straggler).

For V40 assessment, i.e. the equivalent water volume of 40 °C in litres, the current value of 3% was found to be much too low. For the gas-fired storage water heater (111 litres nominal volume) a minmax/avg value of 18% was found. For the dedicated heat pump water heater (300 litres nominal volume) a V40 minmax/avg value of 6% was found. Improvements are needed for the storage technology in general. More analysis is needed on the results to give an idea what could be the tolerance. It is recommended to set tolerances higher or use absolute values for the tolerances on the V40 value.

There is no expert estimate on standby heat loss. The minmax/avg values for solar stores (RRT2, RRT3) are in the range of 11.5-12.5%. For the dedicated heat pump water heater a standby electric standby power of 26W was measured with minmax/avg of 24%, but it is not certain whether this includes the standby heat loss compensation or other issues as well. In any case, the current tolerance of 5% seems low (VHK-opinion).

2.6 Third party verification

Task 1 reports on the ongoing discussion between stakeholders regarding third-party verification of the declared efficiency values. Contrary to space heating performance where, depending on the form of energy input to the appliance, third-party verification is mandatory or not, the water heating performance of dedicated water heaters is not subject to third-party verification.

The ongoing discussion is whether third-party verification should also become mandatory in the scope of the Ecodesign and Energy Label water heating appliances. The main advantages are a higher credibility, less risk of circumvention, a level playing field especially vis-à-vis extra-EU products. Disadvantages are higher costs and longer time-to-market for manufacturers and the need for an expansion of laboratory capacity.

Traditionally, the producers of the gas- and oil-fired heating water heaters are not principally against third-party testing, which is what they are used to for space heating boilers. Electric resistance water heater manufacturers have traditionally been opposed to third-party testing. Heat pump manufacturers, in Europe very often with extra-EU origin (Japan, South-Korea, USA), were traditionally against third-party verification. However, probably because of certification required by support schemes (local and/or national) coupled with the increasing competition of lower quality products, large heat pump manufacturers have now changed opinion and would like a system with more third-party checks. The details of their preferences are not yet fully clear, but there is now a basis
for a design option for third-party verification (that can be discussed in the second stakeholder meeting).

This is an important step in creating a reliable data foundation, not just for this product group, but also for Ecodesign and Energy Labelling as well as related legislation in the context of EPBD and EED.

Note that according to the framework directive, third-party verification can be called for if duly justified and proportionate to the risk. Currently also third-party verification is investigated for the Ecodesign of solid fuel water heaters and space heating boilers in Lot 1.

### 2.7 Ecodesign limits for XXL, 3XL, 4XL

The inhabitants of Norway have the exceptional good fortune to live in a country with abundant supply of carbon-free, low-cost electricity from hydropower. As a consequence, Norway has practically phased out the use of all other energy sources, except wood and solar, in the residential and most other sectors. This means that the current Ecodesign limits of 62 and 64% for XXL, 3XL, 4XL water heating load profiles cannot be met with standard electric resistance (storage) water heaters. New XXL, 3XL, 4XL appliances, which are apparently popular in Norway, should either be using electric (combi or dedicated) heat pumps, biomass or electric resistance heaters assisted by solar collectors to meet the Ecodesign limits. According to the Norwegian government in 2017, none of these options is a full alternative to the electric (storage) resistance heaters for technical reasons --e.g. solar and biomass are difficult in an urban areas and the climate is not very favourable for solar devices-- or economic reasons, e.g. the extra capital costs of heat pump water heating will not be recuperated in electricity saving at the very low electricity tariffs in Norway.

This has been extensively documented in the Commission’s 2016 special water heater study in 2016 and there is little dispute over the state-of-affairs. There is, however, disagreement over the solution.

Norway claims that Article 15, sub 5, sub sub c) applies i.e. that "there shall be no significant negative impact on consumers in particular as regards the affordability and the life cycle cost of the product;" and thus the Ecodesign limits should be lowered to a level that can be accommodated by their current practice of large electric storage water heaters.

The EU Member States were not won over by the argument of the strict and absolute interpretation of the article 15.5c) as was apparent from the stakeholder meeting and consultation forum at the time, but no final decision was reached.

Therefore, during a Consultation Forum meeting on 27 March 2017, it was concluded that the review study would look into the issues raised.

Now, after the second stakeholder meeting of the review study and for the arguments mentioned in paragraph 2.4 there is now a proposal for a technology-specific solution that should solve the Norwegian concern (see par. 2.4).
2.8 Clarification of the product scope

In Art. 2 (definitions) of the regulations, the options of hydrogen and other electrofuels (e-fuels) should be mentioned with the definition of water heaters.

Manufacturers of pool heaters and industrial process water heaters have asked if and how they should meet certain Ecodesign requirements for water heaters. This shows that the current definitions just mentioning “drinking or sanitary hot water” and “connected to an external supply” (of drinking or sanitary water) are not clear enough and need to be improved.
3 OPTIONS FOR SINGLE APPLIANCES

3.1 Introduction

Single water heaters are electric storage water heaters (ESWHs), electric instantaneous water heaters (EIWHs), gas-/oil-fired storage water heaters (GSWHs), gas-/oil-fired instantaneous water heaters (GIWHs), dedicated heat pump water heaters, electric heat pump water heaters (EHPWHs) and thermally driven by a gas-fired heat pump or gas-/oil engine (TDHPWHs). Finally, also hot (drinking or sanitary) water storage tanks are a specific product. All these products are regulated in the Ecodesign regulation 814/2013, albeit currently not technology specific.

They are also regulated in the Energy Label regulation 812/2013 but —on top of these single products— the Energy Label regulation also includes packages of the previously mentioned single types with solar thermal devices (SOL). Note that the Ecodesign regulation does not exclude solar water heaters, but also does not define them as ‘heat generators’ (Art. 2). Packages with solar assistance will be discussed in the next chapter.

After consultation with industry and Member States it was learned that there are little problems with the Ecodesign regulation for dedicated water heaters. The only reported issues relate to:

- The fact that there are 4 different test standards for storage tank standing losses and the transitional method does not choose between them;
- There is a problem with certain water heaters that fall in the 3XL-4XL category for the Ecodesign regulation, but under the current rules should also be tested at XXL tapping pattern for the Energy Label regulation;
- No differentiation between LPG-type (3rd family) and natural gas in NOx-emissions;
- Possibilities to phase out pilot flames.

3.2 Storage tank test standards

Table 7 hereafter shows the specifications for measuring standing loss $S$ of storage tanks according to the transitional method.

In Task 1 there is a discussion of the single standards and also a very detailed comparison (Table 10, par. 3.5.4.7).

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31 This is not derived from the regulation but from the European Commission Guidelines accompanying the boiler and water heater regulations (September 2015).
The conclusions in Task 1 are:

- As the EN 60379 is intended for electric storage heaters, it should not be used for measurement of thermal stores of another kind, with other types of heat generators or heat transfer equipment present.
- EN 12897:2016 and prEN 15332:2016 are fairly comparable in the sense that they both register heat losses over a 24 hour period. Differences are found in the requirements for installation (distance to walls, etc.), the number and position of temperature sensors and the loading of the storage tank.

At the moment the Working Groups responsible for these standards are aligning both standards so that results will become comparable. EN 12897 is considered the more complete standard as it covers various safety requirements as well. But the most recent draft of EN 15332 describes better the testing of tanks with heat exchangers present and possibly filled with water, and offers a more unambiguous way of determining completion of tank charging.

- EN 12977-3 follows a fundamentally different approach: Starting from a defined start-up condition (20 °C) the heater is continuously heated until the tank is fully

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The tank is then allowed to cool down so that between 40% to 60% of stored energy is lost to the ambient. Subsequently the tank is emptied completely and brought back into start-up condition (20 °C). Various temperatures and flows are registered and using a mathematical model, thermal parameters are identified. These parameters are adjusted so that the calculated values and test values match. The benefit is that this test allows determining heat losses of a family of products (up- and downscaling procedure, up to 600 litres).

For the above reasons the following is proposed: Although EN 12897:2016 and prEN 15332:2016 allegedly give comparable results, EN 15332 is preferred as it is less ambiguous as regards testing of tanks with heat exchangers present and determining the charge of the tank. EN 12977-3 might be used for solar storage tanks only. Standard EN 60379 should not be used for the rating of standing losses of the storage tank. The proposal is that the transitional method shall be clarified accordingly.

**Stakeholder comments**

At the second stakeholder meeting interest groups defended their own standard, even EN 60379. Other stakeholders have been critical of the co-existence of 4 different test standards for practically the same thing. Reaction of the study team:

Legislation should be transparent and robust. At the moment, for standby heat loss of storage tanks, it is neither. There are many differences between the standards as regards the position of sensors, procedures for thermal stability, etc.. Reproducibility of storage tank standby heat loss is problematic (see par. 2.5) and overall vis-à-vis the general public and media the credibility of Ecodesign and Energy Labelling of water storage tanks is at stake. If industry in the standardisation groups cannot come to a co-operation and agreement, it is recommended that the legislator sets a single solution.

### 3.3 Micro-CHP

It is proposed to use a calculation method that on one hand is consistent with the principles of the CHP-calculation in the Energy Efficiency Directive but on the other hand recognizes some special characteristics of mCHP as a key instrument for distributed (local) electricity generation with waste heat energy use. The first enhances the credibility of the efficiency numbers and facilitates the incorporation of e.g. financial incentives in the National Energy Efficiency Action Plans (NEEAPs). The second ensures that the efficiency accounting for mCHP will not be negatively affected by an increasing share of renewables in electricity generation.

There will be no immediate impact in terms of costs and benefits for the consumer, but overall the measure will increase the effectiveness and efficiency of the regulation.

The main barrier in developing the mCHP market in the EU is not with the efficiency numbers but with the capital costs.

### 3.4 Energy label 3XL/4XL

This issue has been discussed in Task 1, section 5.3.1. Water heaters (and combi heaters) that have a power output ≤70 kW are subject to both Ecodesign and Energy Label regulations. They should be tested at their maximum load profile or the load profile
one below the load profile. If they are capable of a tapping pattern 3XL/4XL then that is how they should be tested for the Ecodesign regulation. However, energy labelling regulation only goes up to a tapping pattern 2XL. This implies that

- Manufacturers have to test twice, once 2XL for the label and again at 3XL or 4XL for Ecodesign.
- The 2XL tapping pattern is not representative of the real performance and efficiency (because it is oversized)
- Such water heaters (meeting the 3XL or 4XL profile) are primarily for commercial purposes, for which the energy label is not really intended.

The water heating industry has made a joint request to abolish the need to test the 3XL/4XL water heating appliances that have a power output \(\leq 70\ kW\) for energy labelling.

It is proposed to grant this request.

### 3.5 \(\text{NO}_x\)-limits for 3rd family gases

The current regulation sets one \(\text{NO}_x\) limit for all gaseous fuels, i.e. natural gas and LPG. However, for third family gases (propane, butane and their blends) these limits are more difficult to achieve than for natural gas. To correct for this, it is proposed to apply for G30 gases a factor 1.3 on the current \(\text{NO}_x\)-limit (for natural gas) and for G31-gases a factor 1.2. This is in line with the most recent proposal of experts in the relevant EN 15502-1 standard\(^{33}\).

### 3.6 Change in wet bulb temperature of exhaust air DHW HPs

As discussed in Task 1, section 5.3.2 on standard rating conditions, experts agreed that the wet bulb temperature for exhaust air DHW HPs was too low (relative humidity \(\text{rh} \) close to 38\%) and it is proposed to increase this to 15\(^{\circ}\C\) (\(\text{rh} 59\%\)) as in the other "indoor air" category in Table 6 of 812/2013 and Table 4 of 814/2013.

The same change would apply to exhaust air HPs for space heating.

### 3.7 Pilot flame

For space (combi) heaters the pilot flame is extinct and thus it is proposed to phase out the use of pilot flames by setting stringent Ecodesign limits for the overall efficiency.

**Stakeholder comments**

Although Member States did not react against the idea, Sweden brought forward that – instead of explicitly phasing out pilot flames– the limits for gas-fired instantaneous water heaters should be such that it would be no longer possible to use pilot flames.

**Response:** In the newly proposed Ecodesign limits for GIWHs (par. 2.4) it is practically impossible to use pilot flames. But the saving effect of eliminating the pilot flames should not be exaggerated. According to experts in the 2\(^{nd}\) stakeholder meeting, many families

\(^{33}\) EN 15502-1:2012+A1:2015 Gas-fired heating water heaters. General requirements and tests
in Southern Europe turn off the pilot flame during the night and large part of the day. Furthermore, even in the tests of e.g. M-profile and higher GIWHs the pilot flame helps to keep the heat exchanger warm, which means that there almost no waiting time per draw-off compared to a GIWH with a battery ignition. For a GSWH this effect is even bigger, as the pilot flame helps to neutralise the standby heat loss of the storage tank. Nonetheless, especially for smaller GIWHs the saving effect is significant and even for multi-point GIWHs (M or L pattern) there is a 5-8% saving.
4 OPTIONS FOR PACKAGES

4.1 Introduction

Regulation 812/2013 on energy labelling introduces, apart from the energy labels for single products, also an energy label for a package of water heater and solar device.

As has been discussed in Task 1, the Energy Label for Solar devices is not effective in the market. The installers cannot or will not use it and, as has been argued in Chapter 2 on the new labelling limits, there is little reward as often a solar collector does not even raise the Energy Label rating by one class.

4.2 Solar package label

According to stakeholders in the solar thermal industry the current energy label is too complicated for the installer.

The regulation, ANNEX IV, point 4, says that the calculation for the label rating will follow the procedure in Figure 1 of that regulation and uses the following parameters:

- I: the value of the water heating energy efficiency of the water heater, expressed in %;
- II: the value of the mathematical expression \( \frac{220 \cdot Q_{ref}}{Q_{nonsol}} \), where \( Q_{ref} \) is taken from Table 3 in Annex VII and \( Q_{nonsol} \) from the product fiche of the solar device for the declared load profile M, L, XL or XXL of the water heater;
- III: the value of the mathematical expression \( \frac{(Q_{aux} \cdot 2.5)}{(220 \cdot Q_{ref})} \) where \( Q_{aux} \) from the product fiche of the solar device and \( Q_{ref} \) from Table 3 in Annex VII for the declared load profile M, L, XL or XXL of the water heater.

Table 3 in Annex VII contains the load profiles for water heaters and \( Q_{ref} \) is the total energy content of the hot water drawn off over 24h. The number 220 comes from the fact that the load profile represents the peak load; the average load is 60% of the peak load. Instead of saying \( 0.6 \cdot 365 \) days the equation uses the rounded result (220).

The factor 2.5 for the auxiliary (electrical) energy equals CC and should be changed to 2.1.

The task for the installer is to find the appropriate values in the product fiche of the solar collector, find out the water heating efficiency of the water heater and make the calculation. It is not complicated, but it requires paperwork and there is no simple rule-of-thumb in the regulation.
Figure 6. Fiche for a package of water heater and solar device indicating the water heating energy efficiency of the package offered (Figure 1 in Regulation 812/2013)

However, and this might be a problem for small manufacturers, the part of the calculation where the manufacturer has to test and calculate $Q_{nonsol}$ is truly complex, whether you use the SOLCAL or SOLICS.

Thus, it is proposed, as for the (combi-) boilers, to use a simplified installer label for solar assistance. This method was proposed at the second stakeholder meeting. It was...
generally welcomed, but according to experts from Solar Heat Europe\textsuperscript{34} and experts from the Solar Heating Initiative \textsuperscript{35}, the accuracy of this method can be significantly improved, while keeping the simplicity in implementation. The basis is a look-up table of the annual collector output (or the solar enhancement factor), prepared by the manufacturer of the solar heat system.

The inputs for the table are:

- Gross Thermal Yield (GTY) of the solar collector, based on number of modules (or similar)
- Climate (Average, Warmer, Colder)
- Tapping profile (M, L, XL, XXL)

The table would differentiate between water heating and space heating. The figure and table below illustrate the procedure and the table.

![Diagram](image)

\textbf{Figure 7. Options regarding label identification process by the installer (source: Solar Heat Europe 2019)}


Table 8. Options for table to be provided by the manufacturer summarising the solar thermal impact for a given collector type.

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In the case of option 2, the table can be complemented by a calculation for the package efficiency and the reference table from the regulations (space heating or water heating, depending on the case), for installer’s (or other user) convenience.

Figure 8. Solar Enhancement Factor

The Solar Enhancement Factor (or Solar Device Efficiency) should be determined solely with the specifications of the collector, in particular the gross thermal yield. This implies that several assumptions have to be made for other elements, such as the water store, pump or control. Taking the collector as a basis, there are several options in terms of reference methods. These can be grouped into two main streams:

- GTY methods
- EN 15316-4-3, method 2

Solar experts will continue to work on perfecting these two methods. For water heating, as mentioned, the load is the tapping profile selected.

VHK recommends this work continues and finds a place in (forthcoming) standards, so that (after scrutiny and final checks) it can be referenced in the Official Journal as method endorsed by the Commission.
5 ANALYSIS OF OPTIONS

5.1 Introduction
This chapter explores costs and benefits of the options mentioned in the previous sections in as much as possible. Please note that this exploration is bound by the policy objectives and strategies discussed in Task 3. The future role of electric heat pumps, the fuel switch from fossil fuels to carbon-neutral fuels and the role of renewables are considered a given in the context of this review study.

What is important that the cost and benefit aspects of water heating appliances are addressed and as such give a direct input to a review of the regulation and as well contribute to the wider political discussion on the way forward.

Note that this is a first analysis, to be extended after the final stakeholder meeting.

5.2 Horizontal options

5.2.1 H₂-ready
In the recent HyLAW project, the adaptation of end-use gas appliances is mentioned as one of the major barriers for using (carbon-free) hydrogen in the gas grid. This is an aspect where a revised Ecodesign regulation can have a large impact.

According to the H21-report, the total H₂-ready saving for a single consumer, or whoever will pay the bill for the switch-over, would be in the order of €213.

Mainly based on the experience with a town gas-to-natural gas conversion kit in 1966-1970, they estimate that the strict water heater-conversion from natural gas to hydrogen would cost £277.80 (€320). Instead, if the water heater were prepared for the conversion (called “HYSWITCH-ready” in the report), the strict material and labour costs would be £92.60 (€107). These amounts are excluding the replacement of the meters, additional safety features and management mark-up as well as excluding the costs of switching other products such as cookers or dedicated water heaters.

Likewise, another UK source identifies that gas seals, flame detection and the higher flame velocity of hydrogen pose problems for hydrogen combustion. And thus, a grid conversion would reportedly require burner heads and seals to be adjusted/replaced.

However, the study team believes that these sources underestimate the changes in modern water heater technology. More will be needed than a new seal and burner. Atmospheric burners are extinct; almost all burners have (pre-mix) fan-assistance. The higher flame velocity means a (three times) higher flow rate for the fan and —in order to

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36 HyLAW, Horizontal Position Paper Gas Grid Issues, Author: Dennis Hayter, January 2019. www.hylaw.eu
be ready for both natural gas and hydrogen—a continuously variable speed (no single or multi-speed). These specs bring moderate extra costs at the design and production stage, i.e. basically for the higher flow rate because the rest is standard. But changing the fan & drive by the installer gives material and labour cost that easily surpass €300. That is, if it is even possible, because the burner-CPU needs to be prepared in soft- and hardware to regulate the fan. For that, the CPU regulates the fan and gas-valve on the basis of typically—the input from ionisation. But, as is the case with hydrogen, if the ionisation does not work, then it needs to be replaced by a CO or oxygen sensor. In total, for a new burner, seals, pre-mix fan, CO or oxygen sensor and a new burner-CPU to be installed on-the-spot by a specialised installer, the cost will be higher than buying and installing a new hydrogen-fired water heater, which may cost as little as €1400-1500 (incl. VAT) or only 20% more than a natural gas water heater of the same quality.

The reason is that all these design changes lead to much fewer extra costs when anticipated:

- new software for the burner-CPU costs almost nothing;
- CO- or oxygen sensors will probably become the new standard for flame control for quality water heaters anyway and their price should drop as production volume grows;
- the high-flow rate variable speed combustion fans, if needed, will probably be the most expensive item—especially when also a low modulation is required for natural gas operation—but at mass production the prices should become closer to current prices.

As mentioned, the study team estimates these changes to result in €100-150 extra production costs and thus €200-300 extra in consumer price for the average combi water heater.

These are extra acquisition costs for a H₂-ready water heater. The change of burner, seals, etc. could indeed be done at the actual conversion. If the replacement cannot be combined with standard maintenance then a cost of around 100 euro is reasonable (1-2 hours work, modest material costs). Possibly such a—probably not too expensive—conversion kit could be delivered when acquiring the water heater.

### 5.2.2 Biogas

Whereas for the introduction of hydrogen in the gas grid, instead of natural gas, will be a matter of national/international decision making, for biogas it will be a local decision induced by the availability of larger quantities of biogas in the area.

Biogas typically consists of 60-70% methane (CH₄), 30-35% carbon-dioxide (CO₂) and smaller quantities of hydrogen-sulphide H₂S (0.3%), hydrogen H₂ (3%), etc. Also because of the trend towards the larger variation in gas qualities. E.g. the current transition towards 'rich gas' in Belgium.

Biogas can be mixed-in with natural gas (typically up to 10%) and in that case a normal natural gas water heater can be used. For that case no special provisions in the regulation apply.

Alternatively, biogas can be fed directly in a water heater. In that case the water heater should be able to handle the pollutants (resistant materials in seals etc.) and the lower calorific value (typically 21-27 kJ/m³ NCV) as compared to natural gas (34-38 kJ/m³ NCV). In many cases a normal natural gas water heater, when equipped with a good combustion control, can handle that situation but there may be in limitations in the degree of burner modulation. In terms of NOx-emissions there are indications that the presence of CO₂ lowers the emission-level.⁴¹

Tentatively, it is proposed to allow an 1.2 labelling factor for the water heating efficiency if the water heater is placed on the market exclusively for the use with biogas⁴² (exact definition to be supplied). A similar rationale can be applied for water heaters using bio-liquids.

5.2.3 Primary energy factor

As mentioned in section 2, the change in primary energy factor (conversion coefficient CC in the regulation) from 2.5 to 2.1 will not lead to a lower ambition level for the energy efficiency limits of the appliances in the water heater Ecodesign regulation.

Instead, with the proposal for a revised Energy Labelling, the electric solutions and carbon-neutral fuel solutions will be favoured over the fossil fuel heating solutions. This is in line with the EU policy objectives. Whether or not it is in the financial interest of the individual consumers is difficult to say. It can be expected that mass production of the carbon neutral solutions will lower acquisition costs, including more efficiency and know-how with installers.

However, the development of energy tariffs is more difficult to predict. The transition to carbon-free economy in 2050 is likely cause extra societal costs of trillions rather than billions of euros in wind turbines, solar collectors, storage, etc.. Especially given the social unrest (‘gilets jaunes’, fuel poverty, and social politics in general) it is not clear whether and how Member States will finance such a transition and thus also not who will pay what amount of the bill at what time.

5.2.4 Verification tolerances

The ECOTest-project has made and will be making a vital contribution to responsible regulation, which is utterly impossible without having a clearly defined and realistic repeatability and reproducibility of the rules in legislation. For legal disputes on Ecodesign and Energy Labelling, the funding of this type of large inter-laboratory research is essential for the credibility, efficiency and effectiveness of the Ecodesign and Energy Labelling legislation.

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⁴¹ Yungjin Kim, Nobuyuki Kawahara, Kazuya Tsuboi, Eiji Tomita, Combustion characteristics and NOₓ emissions of biogas fuels with various CO₂ contents in a micro co-generation spark-ignition engine, Applied Energy, Volume 182, 15 November 2016, Pages 539-547

⁴² Meaning the manufacturer only assumes liability when used with lower calorific gas.
It is difficult to translate credibility into monetary costs, but the wide reproducibility tolerances on certain heat generators are an important signal to all market actors. Markets and decision makers should be aware that there may be differences, even in fully standardised conditions, of up to 10% between the measurements of reputable and fully accredited test laboratories on the exact same product, despite the fact that each test sequence in a lab takes weeks and costs over €10,000 per product.

In terms of money it means that a consumer may be saving 10% less than what is on the label and that he or she knows that this is the uncertainty margin.

5.2.5 Third-party verification

What goes for the verification tolerances also goes for third-party verification. The only difference, and potentially much more damaging for the credibility of minimum requirements and energy label ratings, is the possibility of circumvention ('cheating').

This is not to say that there is more circumvention in the water heater industry than elsewhere, but the products are usually the largest part of the energy bill and the purchase decision is very often determined by energy saving and payback criteria where circumvention could have a decisive influence. Furthermore, energy labelling is often the basis for financial incentives by public institutions and must be absolutely reliable.

For the producers, third-party verification guarantees a level playing field especially for EU-manufactured vis-à-vis extra-EU products. Disadvantages are of course higher costs, longer time-to-market for manufacturers and the (societal) need for an expansion of laboratory capacity.

For the market surveillance authorities, it is a considerable advantage to be able to rely on accredited laboratory’s reports and cut down on their own spot checks.

5.3 Options for single appliances

5.3.1 Storage tanks

Clarifying the choice of test standard in the transitional method will increase effectiveness of the measure and improve the level playing field between competitors.

5.3.2 Energy Label 3XL/4XL

Restriction of the scope to maximum XXL appliances means half the testing costs for manufacturers and MSAs. It also means that consumers will get better information.

5.3.3 NO\textsubscript{x} limits

LPG-appliances are slightly disadvantaged vis-à-vis natural gas appliances when they have to comply with the same NO\textsubscript{x} limits. A differentiation creates a level playing field.

5.3.4 Sound power measurements

Current description of assessment is unclear and not in conformity with known testing practice. By setting clearer test conditions, the sound power values will be more representative and give a lower administrative burden for industry and MSAs.
5.3.5 Pilot flame
In the worst case pilot flames may consume up to 60 m³ of natural gas (approx. 600 kWh GCV). In an M load profile and an on-mode efficiency of 50-60% this adds some 25% (€40) to the water heater’s energy bill. There are affordable alternatives with short payback times, so there is no reason not to phase out this legacy phenomenon.

5.4 Options for packages

5.4.1 Simplifying solar bonus
At the moment the sales of solar thermal devices are decreasing. Given that these are the renewable, carbon-neutral devices that perfectly fit the EU’s policy goals for energy efficiency and climate change, this has to be turned around. And currently the EU Energy Label is evidently not helping. With the simpler method it is hoped to turn around the situation.
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